

DESCRIPTION

TITLE OF INVENTION:

BINDING SYSTEM AND BINDING PROCESSING PROGRAM

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TECHNICAL FIELD

[0001] The present invention relates to a binding system including a binding machine that binds reinforcing bars with wires and a binding processing program.

10 BACKGROUND ART

[0002] Reinforcing bars are used in concrete structures to improve strength, and the reinforcing bars are bound by a binding machine with wires to be prevented from deviating from predetermined positions during concrete pouring.

In a case of a workpiece in which a plurality of reinforcing bars are arranged to intersect each other, a plurality of intersections between the reinforcing bars are generated. In the related art, it has been proposed to perform binding on such a workpiece at the intersections by a binding robot on which a binding machine is mounted and which moves on the workpiece.

The binding robot acquires the intersections from a camera image of a work area, and circles spirally in the work area to sequentially perform binding at the respective intersections (for example, see Patent Literature 1).

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CITATION LIST

PATENT LITERATURE

[0003] Patent Literature 1: CN110328662A

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] The binding robot in the related art can acquire the intersections from the camera image and autonomously perform binding work at each of the intersections in the work area.

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However, the binding robot only performs control to circle spirally in the work area to sequentially perform binding at each intersection, which lacks versatility in work.

[0005] The present invention has been made to solve such a problem, and an object thereof is to provide a binding system with high versatility in binding work and a binding processing

program.

SOLUTION TO PROBLEM

[0006] In order to solve the above problem, a binding system of the present invention is a binding system that performs binding on a workpiece, having an intersection at which reinforcing bars intersect, at the intersection with a binding body, and includes a control unit configured to allow selection of a binding condition of the binding body at the intersection.

[0007] Further, a binding processing program of the present invention causes a computer that controls a binding system that performs binding on a workpiece, having an intersection at which a plurality of reinforcing bars intersect, at the intersection with a binding body, to implement a function of allowing selection of a binding condition of the binding body at the intersection.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present invention, since the binding condition of the binding body at the intersection is selectable, binding work corresponding to various requirements can be performed on the workpiece, and versatility of the binding system can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0009] [FIG. 1] FIG. 1 is a perspective view of a device body of a binding system according to an embodiment;

[FIG. 2] FIG. 2 is a block diagram illustrating a schematic control configuration of the binding system according to the embodiment;

[FIG. 3] FIG. 3 is a side view of a binding device in a posture when performing a binding operation;

[FIG. 4] FIG. 4 is a schematic diagram of a workpiece on a holding table of a workpiece holding unit as viewed from above;

[FIG. 5] FIG. 5 is a plan view illustrating an intersection at which binding is performed in a first direction among binding directions;

[FIG. 6] FIG. 6 is a plan view illustrating an intersection at which the binding is performed in a second direction among the binding directions;

[FIG. 7] FIG. 7 is a plan view illustrating an intersection at which the binding is performed with the "number of times of binding" being two;

[FIG. 8] FIG. 8 is a plan view illustrating an intersection at which the binding is performed with the number of times of binding in the first direction being one and the number

of times of binding in the second direction being one;

[FIG. 9] FIG. 9 is a diagram illustrating an operation when the binding is performed in a binding order in an (1) outer edge first pattern;

[FIG. 10] FIG. 10 is a diagram illustrating an operation when the binding is performed in a binding order in a (2) center first pattern;

[FIG. 11] FIG. 11 is a diagram illustrating an operation when the binding is performed in a binding order in a (3) transverse feed pattern;

[FIG. 12] FIG. 12 is a diagram illustrating an operation when the binding is performed in a binding order in a (4) longitudinal feed pattern;

[FIG. 13] FIG. 13 is a diagram illustrating an operation when the binding is performed in a binding order in a (5) corner first pattern;

[FIG. 14] FIG. 14 is a diagram illustrating distinction among "intersections located at corners", "intersections located on an outer edge", and other intersections;

[FIG. 15] FIG. 15 is a schematic diagram of a workpiece as viewed from above when an area including intersections serving as binding objects has an irregular shape; and

[FIG. 16] FIG. 16 is a flow chart illustrating a procedure when the binding system performs a binding process.

DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

[0011] [Configuration of Binding System]

FIG. 1 is a perspective view illustrating a device body 10C in a binding system 1C according to the present embodiment, and FIG. 2 is a block diagram illustrating a schematic control configuration of the binding system 1C.

As illustrated in these drawings, the binding system 1C binds, with a wire W as a binding body, a workpiece B in which a plurality of reinforcing bars S are arranged in a grid pattern at intersections P (see FIG. 4) at which the plurality of reinforcing bars S intersect.

Specifically, the binding system 1C includes the device body 10C and a control device 7C.

[0012] The device body 10C includes a workpiece holding unit 2, an entire imaging unit 3, a robotic arm 4, an individual imaging unit 5, and a binding device 6C. Of these, the workpiece holding unit 2 is disposed inside a gantry 11 of the device body 10C, and the entire

imaging unit 3, the robotic arm 4, the individual imaging unit 5, and the binding device 6C are mounted on the gantry 11.

In the following description, X, Y, and Z directions refer to directions illustrated in FIG. 1. The X, Y, and Z directions are orthogonal to each other, an XY plane is a substantially horizontal plane, and the Z direction is a direction substantially along a vertical direction. For the sake of convenience, it is assumed that the X, Y, and Z directions coincide with a coordinate system of a robot in the robotic arm 4 to be described later.

[0013] The gantry 11 is formed in a rectangular parallelepiped shape elongated in the X direction, and includes four support columns 12 erected at four corners in the X direction and the Y direction, and four beams 13 bridged in the X direction and the Y direction at upper ends of the support columns 12.

In an area inside the gantry 11, a substantially half portion on one side (right side in FIG. 1) in the X direction is an imaging area E1 in which imaging by the entire imaging unit 3 is performed, and a half portion on the other side (left side in FIG. 1) is a binding area E2 in which a binding work by the robotic arm 4 and the binding device 6C is performed.

[0014] <Workpiece Holding Unit>

The workpiece holding unit 2 holds the workpiece B and moves the held workpiece B between the imaging area E1 and the binding area E2. Specifically, the workpiece holding unit 2 includes a holding table 21 that holds the workpiece B, a rail 22 that movably supports the holding table 21, and a driving motor 23 that drives the rail 22.

The holding table 21 is formed in a rectangular plate shape having four sides along the X direction and the Y direction. Support plates 211 that support the plurality of reinforcing bars S constituting the workpiece B are erected on the four sides of the holding table 21. Each of the support plates 211 has a plurality of U-shaped grooves 211a opening upward, and the reinforcing bars S are inserted into the U-shaped grooves 211a. The plurality of reinforcing bars S are arranged in a grid pattern along the X direction and the Y direction in a state where ends of the reinforcing bars S are inserted into the U-shaped grooves 211a of the support plates 211.

The rail 22 is laid along the X direction and guides the holding table 21 in the X direction. The rail 22 according to the present embodiment is laid such that the holding table 21 (workpiece B) is movable at least over the imaging area E1 and the binding area E2. However, the rail 22 may be extended to an outside of the gantry 11, and the workpiece B may be movable to a work process before and after binding.

The driving motor 23 is a driving source that causes the holding table 21 to move. The driving motor 23 causes the holding table 21 to move to the imaging area E1 and the binding area E2 based on a driving command from the control device 7C.

[0015] <Entire Imaging Unit>

5 The entire imaging unit 3 images the entire workpiece B in the imaging area E1. Specifically, the entire imaging unit 3 includes a first camera 31 disposed above the imaging area E1 and a movement mechanism 32 that movably supports the first camera 31.

The first camera 31 is disposed to face downward, images the workpiece B held by the workpiece holding unit 2 from above in the imaging area E1, and acquires signal

10 information including information on distances to the reinforcing bars and image information of the workpiece. Specifically, the first camera 31 according to the present embodiment is a compound-eye (for example, four-eye) stereo camera (RGB-D camera), acquires distance information in a depth direction (upper-lower direction) together with image information on the XY plane, and outputs the distance information to the control device 7C. The first camera

15 31 is an example of a first information acquisition unit according to the present invention. A sensor type or the like of the first camera 31 is not particularly limited as long as the first camera 31 can acquire the distance information (depth information) together with the image information, and may be a time of flight (TOF) sensor or the like. Further, a sensor such as a 3D laser scanner or a light detection and ranging (LiDAR) sensor may be used instead of the
20 camera.

The movement mechanism 32 includes a Y direction slider 33 extending along the Y direction. The Y direction slider 33 is bridged over the beams 13 extending along the X direction and is supported by the beams 13 to be movable in the X direction. The first camera 31 is suspended from the Y direction slider 33 to be movable in the Y direction. The
25 movement mechanism 32 drives a driving source (not illustrated) based on a control command from the control device 7C to cause the first camera 31 to move to a predetermined position (XY coordinates).

The movement mechanism 32 is for imaging the entire workpiece B a plurality of times in order to obtain an image of the workpiece B with a desired resolution. Therefore,
30 depending on a performance of the first camera 31, a shape of the workpiece B, and the like, the movement mechanism 32 may include an X direction slider that causes the Y direction slider 33 to move in the X direction, may cause the first camera 31 to move only in one of the X and Y directions, or may not be provided. In addition, when an imaging range of the first

camera 31 is that the entire holding table 21 or the entire workpiece B located in the imaging area E1 can be imaged at one time, the first camera 31 may be fixedly supported at a fixed point.

[0016] <Robotic Arm>

5 The robotic arm 4 is an example of a moving body according to the present invention, is mounted with the individual imaging unit 5 and the binding device 6C, and causes the individual imaging unit 5 and the binding device 6C to move to desired positions in the binding area E2. The robotic arm 4 according to the present embodiment includes a movement mechanism 46, a robotic arm body 40, and a controller 49.

10 [0017] The movement mechanism 46 causes the robotic arm body 40 to move. The movement mechanism 46 according to the present embodiment includes Y direction sliders 461 bridged over the beams 13 of the gantry 11. The Y direction sliders 461 cause the robotic arm body 40 to move in the Y direction.

 However, a specific configuration of the movement mechanism 46 is not
15 particularly limited, and may include, for example, a mechanism that causes the robotic arm body 40 to move in the X direction. In addition, when an operation range of the robotic arm body 40 can cover the entire binding area E2 without depending on the movement mechanism 46, the movement mechanism 46 may not be provided.

[0018] The robotic arm body 40 is a suspended vertical multi-joint robot, and is installed
20 downward on the Y direction sliders 461 bridged over the beams 13 in the binding area E2.

 Specifically, the robotic arm body 40 includes a base 41, a plurality of arms 42, an end effector 43, and a plurality of joints 44.

 The robotic arm body 40 is not limited to the vertical multi-joint robot as long as the robotic arm body 40 can move the individual imaging unit 5 and the binding device 6C
25 mounted thereon.

[0019] The plurality of arms 42 are coupled in series to each other with the base 41 as a proximal end.

 The base 41 is mounted on the Y direction sliders 461 of the movement mechanism 46 and is supported to be movable in the Y direction.

30 The plurality of joints 44 pivotably couple the base 41, the plurality of arms 42, and the end effector 43. Each of the joints 44 is provided with a motor 441 that drives the arm 42 (or the end effector 43) coupled to a distal end side of the joint 44, and an encoder 442 that detects a position (speed) of the motor 441 and outputs the position (speed) to the controller

49.

The end effector 43 is coupled to distal ends of the plurality of arms 42. The individual imaging unit 5 and the binding device 6C are mounted on the end effector 43. A specific configuration of the robotic arm body 40 is not particularly limited as long as the individual imaging unit 5 and the binding device 6C are mounted on a distal end of the robotic arm body 40. For example, the individual imaging unit 5 may be fixed to the joint 44 on the most distal end side, and the binding device 6C may be coupled as an end effector via a tool changer.

[0020] The controller 49 controls an operation of each part of the robotic arm 4 based on a control command from the control device 7C. Specifically, the controller 49 causes each motor 441 and the movement mechanism 46 to operate, and outputs information acquired by each encoder 442 to the control device 7C.

The controller 49 may locally control an operation of the mounted individual imaging unit 5 or binding device 6C based on a control command from the control device 7C.

[0021] <Individual Imaging Unit>

The individual imaging unit 5 is mounted on a distal end of the robotic arm 4 and individually images the intersections P of the reinforcing bars S as binding objects in the binding area E2 with a resolution higher than that of the imaging by the entire imaging unit 3. Specifically, the individual imaging unit 5 includes a second camera 51, an elevator motor 52, and an illumination unit 53.

The second camera 51 is attached to the end effector 43 of the robotic arm 4 in a distal end (downward) direction, and images the intersections P of the reinforcing bars S as the binding objects from above. The second camera 51 is provided to be movable in a distal direction (upper-lower direction) relative to the end effector 43. The second camera 51 according to the present embodiment is, for example, an RGB camera, acquires image information (color image) of the intersections P as the binding objects, and outputs the image information to the control device 7C. The second camera 51 is an example of a second information acquisition unit according to the present invention. A sensor type and the like of the second camera 51 are not particularly limited as long as the second camera 51 can acquire an image of at least one intersection P (signal information of the intersection of the reinforcing bars including an image).

The elevator motor 52 is a driving source that causes the second camera 51 to move (lift and lower) in the distal direction (upper-lower direction) relative to the end effector 43.

The illumination unit 53 is disposed slightly in front of the second camera 51 in an imaging direction and around an imaging range, and illuminates an imaging object of the second camera 51. The illumination unit 53 according to the present embodiment includes a plurality of light sources (light projectors, not illustrated) capable of illuminating the imaging object of the second camera 51 from different angles. The illumination unit 53 may be configured to emit pattern light from a plurality of directions and acquire three-dimensional information around the intersections P in cooperation with the second camera 51.

[0022] <Binding Device>

FIG. 3 is a side view of the binding device 6C in a posture when performing a binding operation.

The binding device 6C is mounted on the distal end of the robotic arm 4. The binding device 6C includes a reinforcing bar binding machine 61C that performs binding at each of the intersections P of the reinforcing bars S constituting the workpiece B with the wires W, a slack forming unit 62C that draws the wires W from reels 63C and forms a slack in the wires W between the binding machine 61C and the reels 63C, and a control unit 64C that causes the reinforcing bar binding machine 61C to perform a binding operation and causes the slack forming unit 62C to perform a slack forming operation of the wires W according to operation commands from the control device 7C.

[0023] The reinforcing bar binding machine 61C has an entry portion 611C into which two wires W are fed from an outside of a case along a feed direction F illustrated in the drawing, and binds the reinforcing bars S with the wires W by winding the two wires W, that are fed from the entry portion 611C into an inside, around the reinforcing bars S, feeding the two wires W wound around the reinforcing bars S in a reverse feed direction R to wind the wires W on the reinforcing bars S, cutting off the wires W, and then twisting the wires W.

[0024] Therefore, the binding machine 61C includes a wire feed unit that feeds the wires W, a wire guide 612C that guides the wires W, a curl guide 613C and an inducing guide 614C that wind the wires W around the reinforcing bars S, a cut unit that cuts the wires W wound on the reinforcing bars S, and a binding unit that twists the wires W wound on the reinforcing bars S.

[0025] The wire guide 612C is provided in front of the entry portion 611C and guides the two wires W to enter the entry portion 611C along the feed direction F.

[0026] The wire feed unit is located inside the entry portion 611C and feeds the two wires W along the feed direction F while clamping the two wires W with a pair of feed gears. The

wire feed unit includes a feeding motor 615C (see FIG. 2) as a driving source. The feeding motor 615C feeds the two wires W in the feed direction F by forward rotation driving, and thus the wires W can be wound around the reinforcing bars S by the curl guide 613C and the inducing guide 614C located ahead of the feeding motor 615C. Further, the feeding motor
 5 615C feeds the two wires W in the reverse feed direction R by reverse rotation driving, and thus the reinforcing bars S can be tightened with the wires W.

[0027] The cut unit is located inside the entry portion 611C and on a further deeper side of the wire feed unit. The cut unit includes a movable blade and a fixed blade (not illustrated), and shares a driving source of the movable blade with the binding unit. The movable blade
 10 can be moved toward the fixed blade by a twisting motor 616C (see FIG. 2), which is a driving source of the binding unit, to cut the two wires.

The driving source of the cut unit may be separately provided.

[0028] The binding device 6C of FIG. 3 is supported by the end effector 43 on the distal end of the robotic arm 4, and performs the binding operation in a state where a turning axis Zr of the end effector 43 is parallel to the Z direction (vertically upper-lower direction). Further,
 15 the binding device 6C is set such that a position at which binding of the reinforcing bars S with the wires W is performed is located on an axis of the turning axis Zr, and the robotic arm 4 positions the binding device 6C during the binding such that each of the intersections P of the reinforcing bars S is on the axis of the turning axis Zr.

20 [0029] The curl guide 613C and the inducing guide 614C are located at a distal end (a lower end during the binding operation) of the binding machine 61C, and are respectively disposed on both sides of the turning axis Zr while sandwiching the turning axis Zr.

A proximal end of the curl guide 613C is disposed ahead of the entry portion 611C in the feed direction F, and a guide path for curling the wires W in a process from the
 25 proximal end toward a distal end of the curl guide 613C is formed inside the curl guide 613C.

[0030] The inducing guide 614C is disposed to face the curl guide 613C, and a guide path for receiving the wires W curled by the curl guide 613C from a distal end and guiding the wires W toward a proximal end while maintaining the curled state is formed inside the inducing guide 614C.

30 By cooperation of the curl guide 613C and the inducing guide 614C, the wires W can be deformed into a loop shape and wound around the reinforcing bars S.

[0031] The binding unit includes a locking member that captures the wires W in a state of being wound around the reinforcing bars S between the proximal end of the inducing guide

614C and the proximal end of the curl guide 613C. The locking member is supported inside the binding machine 61C rotatably around a rotation axis concentric with the turning axis Z_r , and is applied with a torque for performing rotational driving from the twisting motor 616C. The locking member can be rotationally driven by the twisting motor 616C after the wires W are cut by the cut unit, and can twist both ends of the wires W to bind the reinforcing bars S.

[0032] Two reels 63C of the wires W are rotatably supported side by side on one side (an upper side during the binding operation) in a direction along the turning axis Z_r of the binding machine 61C. The two reels 63C are rotatable around an axis along a direction perpendicular to the page in FIG. 3 and are arranged side by side along the same direction.

[0033] As illustrated in FIG. 3, the slack forming unit 62C is disposed on one side in an orthogonal direction X_w orthogonal to the turning axis Z_r with respect to the binding machine 61C and the two reels 63C.

The slack forming unit 62C includes a first slack forming unit 621C and a second slack forming unit 622C that perform mutual crossing operations, and a slack forming motor 623C that is a driving source of the mutual crossing operations.

[0034] The feed direction F of the wires W described above is substantially parallel to a plane parallel to the turning axis Z_r and the orthogonal direction X_w . Further, an upstream side of the feed direction F of the wires W is slightly inclined upward in the paper of FIG. 3 with respect to the orthogonal direction X_w .

Each of the first slack forming unit 621C and the second slack forming unit 622C holds a roller over which the two wires W are stretched.

[0035] Then, each of the first slack forming unit 621C and the second slack forming unit 622C performs the crossing operation substantially along the feed direction F, thus extending a path length of the wire W from the reel 63C to the entry portion 611C of the binding machine 61C and drawing out the wire W from the reel 63C. Further, each of the first slack forming unit 621C and the second slack forming unit 622C performs a restoration operation after the crossing operation, and thus a slack corresponding to an amount drawn out from the reel 63C can be applied to the wire W.

[0036] The two wires W are required to be fed to the entry portion 611C of the binding machine 61C from a direction close to the feed direction F, that is, at an incident angle close to the feed direction F. The feed direction F is a direction suitable for deforming the wires W into an appropriate loop shape by the curl guide 613C and the inducing guide 614C located ahead in an advance direction.

In order to supply the wires W to the entry portion 611C of the binding machine 61C along the feed direction F, the slack forming unit 62C is disposed such that a path from the second slack forming unit 622C on a downstream side to the entry portion 611C of the binding machine 61C is along the feed direction F. Then, during the crossing operation, the second slack forming unit 622C performs a separation movement in a direction away from the entry portion 611C of the binding machine 61C along the feed direction F.

[0037] Therefore, the binding device 6C is disposed such that the slack forming unit 62C largely protrudes on one side (a right side of the page in FIG. 3) in the orthogonal direction Xw with respect to the binding machine 61C (turning axis Zr).

The second camera 51 and the illumination unit 53 of the individual imaging unit 5 are disposed on a left side of the page in FIG. 3 with respect to the binding machine 61C of the binding device 6C.

[0038] <Control Device>

The control device 7C is a computer that integrally controls the binding system 1C. Specifically, the control device 7C includes an operation unit 72, a display unit 73, a storage unit 76C, and a control unit 77C.

The operation unit 72 is an operation unit for a user to perform various operations for operating the control device 7C, and includes, for example, a keyboard and a pointing device such as a mouse.

The display unit 73 is implemented by, for example, a liquid crystal display, an organic EL display, or another display, and displays various information based on a display signal from the control unit 77C. The display unit 73 may be a touch panel that also serves as a part of the operation unit 72, or may output a sound.

[0039] The storage unit 76C is a memory including a RAM (random access memory), a ROM (read only memory), and the like, stores various programs and data, and also functions as a work area of the control unit 77C.

In the storage unit 76C of the present embodiment, a binding processing program 761C for executing a process related to binding to be described later is stored in advance.

Further, the storage unit 76C as a recording device stores image data 762C captured by the first camera 31 and the second camera 51, map data 763C in which information on the workpiece B is recorded, first binding condition data 764C that stores various to-be-described binding conditions selectively set by the user, second binding condition data 765C that stores various binding conditions prepared in advance for executing a plurality of operation modes

to be described later, device information data 766C indicating a three-dimensional position of an entire surface of the binding device 6C, and peripheral information data 767C indicating a three-dimensional position of an entire surface of an obstacle around the robotic arm 4 developed in the coordinate system of the robotic arm 4.

5 [0040] The control unit 77C includes, for example, a CPU (central processing unit) and controls an operation of each unit of the control device 7C. Specifically, the control unit 77C operates each unit of the control device 7C based on an operation content of the operation unit 72 or the like, loads programs stored in advance in the storage unit 76C, and executes various processes in cooperation with the loaded programs.

10 [0041] <Intersection Information Acquisition Process>

By executing the binding processing program 761C described above, the control unit 77C functions as an intersection information acquisition unit that acquires information on the intersections P at which the plurality of reinforcing bars S of the workpiece B intersect.

As described above, the control unit 77C controls the device body 10C to perform
15 binding with the wires W serving as the binding body at each of the intersections P at which the plurality of reinforcing bars S of the workpiece B intersect.

[0042] FIG. 4 is a schematic diagram of the workpiece B held by the support plate 211 of the holding table 21 of the workpiece holding unit 2 as viewed from above in the Z direction. In the schematic diagram, the number of reinforcing bars S of the workpiece B is illustrated to
20 be smaller than that in FIG. 1. Further, a plurality of double circles in the drawing are marks indicating the positions of the intersections P, and do not indicate an object existing on the actual workpiece B. Further, since the number of reinforcing bars S and intersections P in the drawing is large, only some of them are denoted by reference numerals. The same also applies to FIGS. 9 to 15.

25 [0043] The workpiece B has a grid pattern in which a plurality of reinforcing bars S along the Y direction are arranged on a plurality of reinforcing bars S along the X direction. The reinforcing bars S along the X direction and the reinforcing bars S along the Y direction may be upside down. Further, the plurality of reinforcing bars S along each direction are illustrated in a state of being arranged at uniform intervals, but the inter-intervals between the
30 reinforcing bars S may not be uniform. Further, a length may not be uniform.

Positions where center lines of the plurality of reinforcing bars S along the X direction and the plurality of reinforcing bars S along the Y direction intersect when viewed from the Z direction are the intersections P, and the binding system 1C can set each of the

intersections P as a binding object.

[0044] For a binding operation control of the control unit 77C, the information on the intersections P for specifying the positions of the intersections P at which the reinforcing bars S of the workpiece B intersect is necessary.

5 Therefore, the control unit 77C functioning as the intersection information acquisition unit performs a first acquisition process of acquiring the position of each intersection P from the image data 762C captured by the first camera 31 or the second camera 51, and a second acquisition process of acquiring the map data 763C from an outside of the binding system 1C.

10 [0045] The control unit 77C may be configured to perform only one of the first acquisition process and the second acquisition process.

For example, when the control unit 77C is configured to perform only the first acquisition process, the storage unit 76C may be configured not to hold the map data 763C.

[0046] In the first acquisition process performed by the control unit 77C, when the image
15 data 762C of the workpiece B on the holding table 21 captured by the first camera 31 or the second camera 51 is two-dimensional planar image data, a position of a contour of each of the reinforcing bars S in the image is extracted by known image processing, the center line passing through a center of each reinforcing bar S is obtained, and a position at which the center lines of the reinforcing bars S intersect each other is specified, and is acquired as the
20 position of the intersection P. Further, height information of the intersection P may be obtained by performing imaging two or more times while changing a relative position between the first camera 31 or the second camera 51 and the workpiece B on the holding table 21, and calculating a height of each position in the image by parallax. Since three-dimensional position data of all the intersections P of the reinforcing bars S of the workpiece B is obtained
25 in this way, by developing the three-dimensional position data in the coordinate system of the robotic arm 4, the information on the intersections P for specifying the positions of the intersections P is acquired.

[0047] When the image data 762C of the first camera 31 or the second camera 51 is image
30 data including three-dimensional position information, the position information indicated by the image data is developed in the coordinate system of the robotic arm 4 to acquire the information on the intersections P for specifying the positions of the intersections P.

[0048] The control device 7C includes a communication device (not illustrated) that communicates with the outside of the binding system 1C, and the second acquisition process

performed by the control unit 77C is a process of requesting and acquiring the map data 763C from another external information processing terminal via a communication network.

Further, the control device 7C may include a reading device (not illustrated) that reads a storage medium storing the map data 763C, and may acquire the map data 763C by reading from the storage medium.

[0049] The map data 763C records design information of the workpiece B and the like, and includes basic dimensions and three-dimensional position information of each reinforcing bar S and the three-dimensional position information of each intersection P.

Therefore, the control unit 77C that performs the second acquisition process develops the three-dimensional position information of the respective intersections P obtained from the map data 763C in the coordinate system of the robotic arm 4 to acquire the information on the intersections P for specifying the positions of the intersections P.

[0050] <Binding Condition Selection Process>

By executing the binding processing program 761C described above, the control unit 77C performs a process of receiving a selection of the binding condition of the wire W for each of the intersections P of the plurality of reinforcing bars S of the workpiece B, generating the first binding condition data 764C, and storing the first binding condition data 764C in the storage unit 76C.

The binding operation control of the control unit 77C follows various binding conditions. The user can set and input various binding conditions via the operation unit 72 serving as a condition input unit, and the control unit 77C selects various set binding conditions and performs an operation control on the binding work.

Here, the various binding conditions will be described. Each of the binding conditions to be described below is an example and is not limited thereto.

[0051] The binding conditions included in the first binding condition data 764C include a "presence or absence of binding", a "binding direction", the "number of times of binding", and a "binding strength" for each of the intersections P.

The binding conditions further include a "binding order" for the plurality of intersections P of the workpiece B.

These binding conditions will be individually described.

[0052] The "presence or absence of binding" as the binding condition is individually selected for all the intersections P in the workpiece B. The "presence or absence of binding" is a setting on whether each of the intersections P is the binding object. That is, it is possible to

select whether to perform binding for each of the intersections P in the workpiece B.

In the "presence or absence of binding", the user sets and inputs, via the operation unit 72, whether each of the intersections P of the workpiece B is individually set as the binding object, and the control unit 77C selects the intersection P set as the binding object and performs binding.

[0053] The "binding direction" as the binding condition is individually selected for all the intersections P set as the binding objects in the workpiece B. The "binding direction" will be described with reference to FIGS. 5 and 6.

FIGS. 5 and 6 are plan views illustrating two types of binding directions for the intersection P. The wires W bound at the intersection P of the reinforcing bar S in the X direction and the reinforcing bar S in the Y direction is in one of a direction illustrated in FIG. 5 and a direction illustrated in FIG. 6 inclined by approximately 45° with respect to both the X direction and the Y direction when viewed from above in the Z direction. Here, a binding direction along an upper right direction on the page of FIG. 5 is set as a first direction, and a binding direction along an upper left direction on the page of FIG. 6 is set as a second direction.

The "binding direction" as the binding condition indicates whether the binding with the wires W is performed along the first direction or the second direction.

The "binding direction" referred to here indicates a direction along which the wires W after binding extend, as viewed from a vertical direction of the planar workpiece B.

[0054] The binding device 6C of the binding system 1C has a specification of performing binding with two wires W by one binding operation, and the two wires W illustrated in FIGS. 5 and 6 are illustrated in a state after one binding operation. The same applies to the subsequent drawings.

Both ends of each wire W after binding are formed with a wound portion by a twisting operation, but the wound portion is not illustrated in FIG. 5 and the subsequent drawings.

[0055] The "number of times of binding" as the binding condition is individually selected for all the intersections P set as the binding objects in the workpiece B. The "number of times of binding" will be described with reference to FIG. 7.

The "number of times of binding" is the number of times the binding operation is performed by the binding device 6C on one intersection P. The number of wires W used for the binding is proportional to the number of times of binding operations. FIG. 7 illustrates a

bound state when the "number of times of binding" is two. As described above, since two wires W are used in one binding operation, the binding is performed with four wires W at the intersection P. The "number of times of binding" can be selected from one to a plurality of times. However, when the number of times of binding is repeated, a bundle of the wires W wound at the intersection P becomes too large, and thus there is a limit for the number of times.

[0056] Further, the "number of times of binding" as the binding condition may be selectable in combination with the "binding direction".

For example, both the first direction and the second direction may be selected as the "binding direction", and the "number of times of binding" may be selected for each of the directions. FIG. 8 shows a bound state when the number of times of binding is selected as one for the first direction and the number of times of binding is selected as one for the second direction.

In this case, an order of the binding operation in the first direction and the binding operation in the second direction may also be selectable as the binding condition.

[0057] The "binding strength" as the binding condition is individually selected for all the intersections P set as the binding objects in the workpiece B. The "binding strength" indicates a winding strength of the wire W for binding the intersection P. The "binding strength" may be selected as a numerical value or may be selected as a level of strength (for example, strong, medium, weak, or the like).

As described above, the binding device 6C forms a wound portion by the twisting operation on both ends of the wire W. The "binding strength" can be determined by magnitude of a torque generated by the twisting motor 616C of the binding device 6C that performs the twisting operation of the wire W.

For example, when there is a correlation between a torque output by the twisting motor 616C and a value of a current flowing through the twisting motor 616C, the control unit 77C monitors the value of the current flowing through the twisting motor 616C of the binding device 6C and controls the twisting motor 616C to perform the twisting operation on both ends of the wire W until the value of the current reaches a current value corresponding to the torque corresponding to the selection of the "binding strength".

[0058] The "binding order" as the binding condition will be described. The "binding order" can be selected from patterns such as (1) outer edge first, (2) center first, (3) transverse feed (Y direction), (4) longitudinal feed (X direction), and (5) corner first. These patterns are

examples, and other patterns may be selectable.

For example, when a certain one of these patterns (1) to (5) is selectively set by the user via the operation unit 72, the control unit 77C performs binding for the plurality of intersections P according to an order determined in the set pattern.

5 [0059] FIG. 9 shows an order of advancing for each intersection P in the (1) outer edge first pattern. When the (1) outer edge first pattern is selected, the control unit 77C preferentially performs binding at the intersections P located on an outer edge of an area where all the intersections P set as the binding objects of the workpiece B are present.

10 For example, when all the intersections P illustrated in FIG. 9 are binding objects and an area where the intersections P are present is a rectangle, the control unit 77C performs the binding first at the intersections P located at four corners of the rectangular area and on an outer edge along four sides.

[0060] In the (1) outer edge first pattern, the binding is started from the intersection P located at any one of the four corners, and the binding is performed for each of the
15 intersections P while circling in a predetermined direction around the outer edge of the area where the intersections P are present.

From which of the four corners the binding is started can be selectively set via the operation unit 72 by the user, or it may be determined in advance that a corner at a predetermined position is a start position.

20 Further, in FIG. 9, a case where the binding is performed by circling in a clockwise direction on the page of the drawing is illustrated, but the binding is not limited thereto, and may be performed in a counterclockwise direction. The circling direction can be selectively set by the user via the operation unit 72, or a predetermined circling direction may be determined in advance.

25 [0061] Further, in the (1) outer edge first pattern, for the intersections P other than those on the outer edge, as in the example of FIG. 9, the binding for each of the intersections P may be performed while circling in a predetermined direction around an outer edge of an area including the remaining intersections P, and the circling may be similarly repeated inward until the binding is completed for all the intersections P.

30 In this case, regarding a direction of circling in each round, it is preferable that the circling is performed in a reverse direction of circling in a previous round every time one round of circling is performed. The robotic arm body 40 of the robotic arm 4 that moves the binding device 6C performs the binding operation while performing a turning operation in a

state where the turning axis around the axis along the Z direction is aligned with a center position of the workpiece B, and a turning angle range around the axis along the Z direction of the robotic arm body 40 may be limited to approximately 360°. This is because, when the binding is performed by circling as described above, it is possible to reduce an influence of a limitation on the turning angle range of the robotic arm body 40 by alternately switching a turning direction.

When the turning angle range of the robotic arm body 40 is sufficiently wide, circling in a certain direction may be continuously performed.

[0062] FIG. 10 shows an order of advancing for each intersection P in the (2) center first pattern. When the (2) center first pattern is selected, the control unit 77C starts the binding from the intersection P closest to a center of the area where all the intersections P set as the binding objects of the workpiece B are present. The center of the area may be defined as, for example, a geometric center (centroid). Further, when the area in which all the intersections P set as the binding objects of the workpiece B are present is not a rectangle, a centroid of a rectangle in which the area is inscribed may be defined as the center of the area.

[0063] For example, in a case where all the intersections P illustrated in FIG. 10 are binding objects and an area where the intersections P are present is a rectangle, when the (2) center first pattern is selected, the control unit 77C performs the binding in order starting from the intersection P at the center, shifting to the intersection P located therearound and advancing toward the intersections P on an outer side while circling.

[0064] In the (2) center first pattern, as illustrated in FIG. 10, the circling direction is alternately switched between the clockwise direction and the counterclockwise direction on the page of the drawing every time one round of circling is performed. A reason is the same as the reason for alternately switching the circling direction in the (1) outer edge first pattern described above.

When the turning angle range of the robotic arm body 40 is sufficiently wide, circling in a certain direction may be continuously performed.

[0065] FIG. 11 shows an order of advancing for each intersection P in the (3) transverse feed pattern. When the (3) transverse feed pattern is selected, the control unit 77C starts the binding from a row of intersections P closest to one side in the Y direction among rows of the intersections P arranged along the X direction in the area where all the intersections P set as the binding objects of the workpiece B are present, and performs the binding row by row in order in the Y direction.

[0066] From which row on both ends in the Y direction among a plurality of rows of the intersections P arranged along the X direction the binding is started, or from which intersection P on both ends of the row of intersections P arranged along the X direction the binding is started, may be selectively set by the user via the operation unit 72, or may be
 5 determined in advance.

FIG. 11 illustrates a case where the advance direction of the binding in a row of intersections P arranged along the X direction is a reverse direction of an immediately preceding row. Thus, a movement amount for each of the intersections P of the workpiece B can be reduced, and the work can be quickly performed.

10 [0067] In the example of FIG. 11, the binding is performed for the rows of the intersections P arranged along the X direction row by row in order in the Y direction, but the present disclosure is not limited thereto. For example, the binding may be alternately advanced in a row on one end side and a row on the other end side in the Y direction among the rows of the intersections P arranged along the X direction, and the binding may be completed at a row in
 15 the middle in the Y direction.

[0068] FIG. 12 shows an order of advancing for each intersection P in the (4) longitudinal feed pattern. When the (4) longitudinal feed pattern is selected, the control unit 77C starts the binding from a row of intersections P closest to one side in the X direction among rows of the intersections P arranged along the Y direction in the area where all the intersections P set as
 20 the binding objects of the workpiece B are present, and performs the binding row by row in order in the X direction.

[0069] From which row on both ends in the X direction among a plurality of rows of the intersections P arranged along the Y direction the binding is started, or from which intersection P on both ends of the row of intersections P arranged along the Y direction the
 25 binding is started, may be selectively set by the user via the operation unit 72, or may be determined in advance.

FIG. 12 illustrates a case where the advance direction of the binding in a row of intersections P arranged along the Y direction is a reverse direction of an immediately preceding row. Thus, a movement amount for each of the intersections P of the workpiece B
 30 can be reduced, and the work can be quickly performed.

[0070] In the example of FIG. 12, the binding is performed for the rows of the intersections P arranged along the Y direction row by row in order in the X direction, but the present disclosure is not limited thereto. For example, the binding may be alternately advanced in a

row on one end side and a row on the other end side in the X direction among the rows of the intersections P arranged along the Y direction, and the binding may be completed at a row in the middle in the X direction.

[0071] FIG. 13 shows an order of advancing for each intersection P in the (5) corner first pattern. When the (5) corner first pattern is selected, the control unit 77C first performs the binding at the intersection P located at a corner of the area where all the intersections P set as the binding objects of the workpiece B are present.

For example, when all the intersections P illustrated in FIG. 13 are binding objects and an area where the intersections P are present is a rectangle, the control unit 77C specifies the intersection P located at the corner of the rectangle and performs binding first at the intersection P.

[0072] In the (5) corner first pattern, the binding is performed in a predetermined order for each of the intersections P located at four corners.

The order in which the binding is performed for each of the intersections P at the four corners may be selectively set by the user via the operation unit 72, or a predetermined order may be determined in advance. For example, the binding may be performed to circle from a first intersection P among the intersections P at the four corners, the binding may be performed for a next intersection P located diagonally with respect to the first intersection P among the intersections P at the four corners, and the binding may be similarly performed at the intersections P at the remaining two corners.

[0073] Further, in the (5) corner first pattern, any one of the patterns (1) to (4) described above may be performed for a binding order at the intersections P other than those at the corners. Therefore, when the (5) corner first pattern is selected, any one of the patterns (1) to (4) may be selectable for the intersections P other than those at the corners. The selection may be selectively set by the user via the operation unit 72, or any one of the patterns (1) to (4) may be determined in advance as a predetermined setting.

[0074] When the "binding order" as the binding condition is selected, the control unit 77C needs to specify the "intersections P located at the corners" and the "intersections P located on the outer edge" in the area where the intersections P are present.

FIG. 14 is a diagram in which the "intersections P located at the corners" are indicated by "A", the "intersections P located on the outer edges" are indicated by "B", and other intersections P are indicated by "C".

[0075] In FIG. 14, the control unit 77C specifies the intersections P each having two other

adjacent intersections P as the "intersections P located at the corners", such as the intersections P denoted by "A" in an area Ra surrounded by a two-dot chain line.

In FIG. 14, the control unit 77C specifies the intersections P each having three or less other adjacent intersections P as the "intersections P located on the outer edge", such as the intersections P denoted by "B" in an area Rb surrounded by a two-dot chain line.

In FIG. 14, the control unit 77C specifies the intersections P each having four other adjacent intersections P as the intersections P other than the "intersections P located at the corners" and the "intersections P located on the outer edge", such as the intersections P denoted by "C" in an area Rc surrounded by a two-dot chain line.

[0076] The "adjacent intersections P" indicate a case of being adjacent via the reinforcing bar S. That is, the adjacent intersections P indicate intersections P adjacent in the X direction or the Y direction, and do not include intersections P adjacent in a direction oblique to both the X direction and the Y direction.

Since the "intersections P located on the outer edge" are intersections each having three or less other adjacent intersections P, the "intersections P located at the corners" each having two other adjacent intersections P are also included.

[0077] Further, regarding the patterns (1) to (5) in the "binding order", the case where all the intersections P are the binding objects and the area where the intersections P are present is a rectangle has been described as an example, but a part of the intersections P may not be the binding objects or the workpiece B may not have a rectangular planar grid shape but have a partially missing shape.

For example, when the workpiece B is installed in a place where an obstacle, such as a support column, is present, a part of the reinforcing bars S is removed to avoid the obstacle in advance or after the binding work at the intersections P, and the workpiece B has a missing shape. Further, the intersections P within a range in which a part of the reinforcing bars S is scheduled to be removed due to the obstacle may not be the binding object.

[0078] FIG. 15 is a schematic diagram of the workpiece B on the holding table 21 as viewed from above, illustrating a case where a part of the intersections P is not the binding object or a part of the reinforcing bars S of the workpiece B is removed and a part of the rectangle is lost, and an area in which the binding object is set has an irregular shape. It is assumed that all the intersections P indicated by double-circle marks illustrated in the drawing are the binding objects.

[0079] In a case of the area having such an irregular shape, the control unit 77C can also

perform the binding according to an order determined in the patterns (1) to (5) by specifying the "intersections P located at the corners", the "intersections P located on the outer edge", and other intersections P according to the above definition.

[0080] For example, as illustrated in FIG. 15, all the intersections P numbered inside are the "intersections P located on the outer edge", and among these intersections P, the intersections P numbered "1", "7", "13", "17", and "21" are the "intersections P located at the corners".

[0081] Therefore, in the (1) outer edge first pattern, the binding may be performed first at the intersections P numbered "1" to "33". In this case, for example, the binding may be performed in numerical order.

Further, in the (2) center first pattern, a center of the area may be obtained according to the above definition, and the binding may be performed from the intersection P close to the center.

Further, in the (3) transverse feed pattern, the binding may be performed in the order described above for a plurality of rows of the intersections P arranged along the X direction.

Further, in the (4) longitudinal feed pattern, the binding may be performed in the order described above for a plurality of rows of the intersections P arranged along the Y direction.

Further, in the (5) corner first pattern, the binding may be performed first at the intersections P numbered "1", "7", "13", "17", and "21".

[0082] In the binding system 1C, as described above, the "presence or absence of binding", the "binding direction", the "number of times of binding", the "binding strength", and the "binding order" serving as the binding conditions can all be selectively set by the user via the operation unit 72. When these conditions are selected, the control unit 77C generates the first binding condition data 764C defining the binding conditions according to the selective setting, and records the first binding condition data 764C in the storage unit 76C.

The control unit 77C can read the first binding condition data 764C many times, read the same first binding condition data 764C every time for a plurality of workpieces B, and perform the binding operation control according to the same binding conditions.

When the user selectively sets another content for each binding condition via the operation unit 72, new first binding condition data 764C is generated and recorded in the storage unit 76C. In this case, the already existing first binding condition data 764C and the

new first binding condition data 764C are recorded to include identification information so as to be able to be identified from each other, and the individual first binding condition data 764C can be selected to perform the binding operation control.

[0083] <Operation Mode as Binding Condition>

5 Further, in the storage unit 76C, in order to reduce a work load of the user selectively setting all the binding conditions via the operation unit 72, a plurality of pieces of second binding condition data 765C in which contents of the "presence or absence of binding", the "binding direction", the "number of times of binding", the "binding strength", and the "binding order" are determined in advance are prepared in the storage unit 76C.

10 The plurality of pieces of second binding condition data 765C are individually associated with a plurality of operation modes, respectively, and the control unit 77C can read the corresponding second binding condition data 765C according to the selected operation mode and perform the binding operation on each intersection P.

Examples of the operation mode include a "normal mode", a "strength prioritized mode", and a "speed prioritized mode". Hereinafter, these various operation modes will be described.

[0084] The "normal mode" is a mode for performing normal binding. In principle, the "normal mode" can be selected by the user. Further, even in a case where the user inputs execution of the binding operation without selecting the "presence or absence of binding", the "binding direction", the "number of times of binding", the "binding strength", and the "binding order", and selecting the operation mode, the "normal mode" is automatically selected, and the binding operation is executed.

For example, the "normal mode" is set such that, regarding the "presence or absence of binding", all the intersections P in the workpiece B are set as binding objects.

25 Further, the "binding direction" is set such that all the intersections P in the workpiece B are in either the first direction or the second direction, and each of the intersections P is different in the "binding direction" from another adjacent intersection P. That is, the binding is performed in a staggered arrangement in which the binding in the first direction and the binding in the second direction are alternately performed in the X direction for all the intersections P in the workpiece B, and the binding in the first direction and the binding in the second direction are alternately performed in the Y direction for all the intersections P in the workpiece B.

Further, the "number of times of binding" is set such that the binding is performed

once for all the intersections P in the workpiece B.

The "binding strength" is set to a predetermined standard value.

Further, the "binding order" is set to the (1) outer edge first.

[0085] The "strength prioritized mode" is a mode for performing the binding with a higher
5 binding strength than in the "normal mode".

The "strength prioritized mode" is the same as the "normal mode" except for the
"binding strength" among the various setting conditions.

The "strength prioritized mode" is set such that the "binding strength" is a numerical
value higher than a predetermined standard value (for example, about 1.2 times to 2 times the
10 standard value).

[0086] The "speed prioritized mode" is a mode for performing the binding more quickly
than in the "normal mode".

The "speed prioritized mode" is the same as the "normal mode" except for the
"binding direction" and the "binding order" among the various setting conditions.

15 In the "speed prioritized mode", regarding the "binding direction", all the
intersections P in the workpiece B are aligned in the first direction (or the second direction),
and a frequency of the turning operation of the binding device 6C around the axis along the Z
direction is reduced to accelerate a continuous binding operation.

In the "speed prioritized mode", either the (1) outer edge first or the (2) center first
20 is set for the "binding order". In any "binding order", a path from a first intersection P to a last
intersection P does not pass through the same position in an overlapping manner, and the
binding work can be accelerated. Further, since a distance between the first intersection P at
which the binding is started and the last intersection P is shorter than that in the (3) transverse
feed or the (4) longitudinal feed, it is possible to accelerate a restoration operation to a start
25 position of binding for the next workpiece B when the binding is continuously performed for
a plurality of workpieces B.

[0087] <Operation of Binding System>

Subsequently, an operation of the binding system 1C will be described.

FIG. 16 is a flow chart illustrating a procedure when the binding system 1C
30 performs a binding process.

The CPU of the control unit 77C of the control device 7C performs the following
binding process according to the binding processing program 761C.

[0088] By executing the binding processing program 761C, the control unit 77C functions

as the intersection information acquisition unit, and performs a process of acquiring the information on the intersections P at which the plurality of reinforcing bars S of the workpiece B intersect.

In this case, the control unit 77C determines whether use of the map data 763C is selected by the user through the operation unit 72, for example (step S101).

[0089] When the use of the map data 763C is selected, the control unit 77C reads the map data 763C from the storage unit 76C (step S103). At this time, when the map data 763C is not prepared in the storage unit 76C, the map data 763C is acquired by communicating with the outside or reading a recording medium.

[0090] On the other hand, when the use of the map data 763C is not selected, the control unit 77C causes the first camera 31 of the entire imaging unit 3 to image the entire workpiece B on the holding table 21 of the workpiece holding unit 2 disposed in the imaging area E1 of the gantry 11 (step S105).

[0091] When the map data 763C is read or the workpiece B is imaged by the first camera 31, the control unit 77C acquires three-dimensional position data of all the intersections P of the reinforcing bars S of the workpiece B based on the map data 763C or the image data 762C, and develops the three-dimensional position data in the coordinate system of the robotic arm 4. Accordingly, the positions of all the intersections P can be specified (step S107).

Therefore, the control unit 77C functions as an intersection specifying unit.

[0092] Next, the control unit 77C drives the driving motor 23 of the workpiece holding unit 2 to cause the holding table 21 and the workpiece B to move to the binding area E2 (step S109).

[0093] Next, the control unit 77C determines whether use of the first binding condition data 764C in which the user individually selectively sets each of the binding conditions is selected (step S111).

When the use of the first binding condition data 764C is selected, the first binding condition data 764C in the storage unit 76C is further read (step S113). At this time, when a plurality of pieces of first binding condition data 764C are held in the storage unit 76C, a specific piece of first binding condition data 764C is read according to the selection of the user. Then, the process proceeds to step S121.

[0094] On the other hand, when the use of the first binding condition data 764C is not selected, the control unit 77C determines whether the operation mode is selected (step S115).

Then, when the operation mode is selected, the control unit 77C determines which of the "normal mode", the "strength prioritized mode", and the "speed prioritized mode" is to be executed in response to the selection of the user, and reads the setting conditions from a corresponding piece of the second binding condition data 765C in the storage unit 76C

5 according to the selected operation mode. Then, the process proceeds to step S121.

[0095] Further, in step S115, when it is determined that the operation mode is not selected, the control unit 77C selects the "normal mode" (step S119), and reads the setting conditions from a corresponding piece of the second binding condition data 765C in the storage unit 76C. Then, the process proceeds to step S121.

10 [0096] In step S121, the control unit 77C specifies the intersection P at which the binding is to be performed first on the workpiece B based on the selection of the "presence or absence of binding" and the "binding order" in the binding conditions acquired in step S113, step S117, or step S119. Further, the control unit 77C obtains position coordinates of the intersection P at which the binding is to be performed first, based on the information on the intersections P for specifying the positions of the intersections P acquired in step S107.

[0097] The control unit 77C controls the robotic arm 4 to position the second camera 51 at an imaging position of the intersection P at which the binding is to be performed first, and moves the second camera 51 closer to the intersection P by driving the elevator motor 52 (step S121).

20 [0098] Next, the control unit 77C images the intersection P by the second camera 51 (step S123).

The second camera 51 can obtain a position of the intersection P with higher accuracy based on the image data 762C by imaging the intersection P from a position closer to the intersection P than the position of the first camera 31.

25 [0099] Therefore, the control unit 77C newly calculates a position of the intersection P based on the image data 762C obtained by the second camera 51 (step S125), and positions the binding position of the binding device 6C closer to the newly obtained position of the intersection P (step S127).

30 At this time, the control unit 77C determines an orientation of the binding device 6C about the axis along the Z direction according to the "binding direction" included in the binding conditions acquired in step S113, step S117, or step S119.

[0100] The control unit 77C operates the binding device 6C to perform binding with the wires W at the intersection P (step S129).

At this time, the control unit 77C performs the binding with the wires W according to the "number of times of binding" and the "binding strength" (also including the "binding direction" when the "number of times of binding" and the "binding direction" are selected in combination) in the binding conditions acquired in step S113, step S117, or step S119.

5 [0101] Then, the control unit 77C determines whether the intersection P at which the binding is performed is a last intersection P based on the positions of all the intersections P from the information on the intersections P for specifying the positions of the intersections P acquired in step S107 and the selection of the "presence or absence of binding" and the "binding order" in the binding conditions acquired in step S113, step S117, or step S119 (step
10 S131).

Thereby, when the intersection P at which the binding is performed is not the last intersection P, the control unit 77C specifies the intersection P at which binding is to be performed next (step S133), and repeats the processes from step S121 to step S133.

On the other hand, when the intersection P at which the binding is performed is the
15 last intersection P, the control unit 77C ends the binding process on the workpiece B.

[0102] <Technical Effects of Invention>

The control device 7C of the binding system 1C includes the control unit 77C that allows selection of the binding condition of the wire W at each of the intersections P of the reinforcing bars S of the workpiece B.

20 Therefore, by appropriately selecting a content of the binding condition, an appropriate binding process of the wire W can be performed for various workpieces B, and the binding system 1C with high versatility can be provided.

[0103] Further, the control unit 77C of the control device 7C of the binding system 1C allows a binding order of the wire W at the plurality of intersections P of the workpiece B to
25 be selected from among a plurality of patterns, as the binding condition.

Therefore, it is possible to implement strong binding and binding with a quick work speed for the workpiece B.

[0104] In particular, since the control unit 77C allows selection of a plurality of operation modes in each of which the binding order of the wire W at the plurality of intersections P of
30 the workpiece B is specified, in the binding process of the workpiece B, the binding with the wire W at the respective intersections P can be performed in an appropriate order according to a purpose.

[0105] Further, in a part or all of the selectable operation modes, the binding with the wire

W at the plurality of intersections P is performed from an outer edge of the workpiece B along the outer edge.

Since both ends of each of the plurality of reinforcing bars S constituting the workpiece B are supported by the support plate 211 of the holding table 21 in a state before binding, deflection is likely to occur in a central portion, and a gap is likely to be generated in the central portion in a state where the reinforcing bars S are vertically stacked. In this case, by performing the binding first from the intersections P on the outer edge, the gap between the upper and lower reinforcing bars S before performing the binding at the central portion of the reinforcing bars S can be reduced, and a deflection amount of each of the reinforcing bars S when performing the binding at the central portion can be reduced. Therefore, a deviation after binding generated in each part of the workpiece B due to the deflection of the reinforcing bars S caused by the binding at the central portion can be prevented. The outer edge described here indicates an outermost side of an entire area including an area close to an inner side and an area close to an outer side of the workpiece B, and the outer side indicates an outermost side of the workpiece including a regularly continuous intersection group. That is, the binding from the outer edge indicates binding from intersections facing an external space for workpieces having various shapes. The external space is a space that does not constitute the intersection group, and includes a space around the workpiece and a space provided inside the workpiece.

[0106] Further, the control device 7C of the binding system 1C includes the operation unit 72 for inputting the binding condition, and the control unit 77C performs the binding with the wire W at the plurality of intersections P according to the binding condition input from the operation unit 72.

Therefore, a user can easily select the binding condition corresponding to the actual workpiece B, and can appropriately select the binding condition for various workpieces B or irregular workpieces B to implement strong binding, quick binding, or smooth binding.

[0107] Further, since the control unit 77C of the control device 7C of the binding system 1C functions as the intersection information acquisition unit for acquiring information on the intersections P and the intersection specifying unit for specifying the intersection P at which the binding with the wire W is to be performed, based on the acquired information on the intersections P of the workpiece B, the binding work can be performed from a position corresponding to the intersection P of the workpiece B at which the binding is to be performed, the binding work can be optimized, and good binding can be provided.

[0108] Further, since the binding system 1C includes the storage unit 76C capable of recording the map data 763C which is acquired from an outside and is the information on the intersections P, the position of the intersection P can be specified from the map data 763C prepared outside.

5 Therefore, the positions of all the intersections P of the workpiece B can be acquired without performing processing such as imaging the workpiece B, extracting the intersections from image data obtained by the imaging, specifying positions of the intersections, and the like, the binding process can be accelerated, and a processing load and the like can be reduced.

10 [0109] Since the control unit 77C of the control device 7C executes the binding processing program 761C to implement the function of allowing the selection of the binding conditions, the function can be easily obtained from the existing binding system without increasing new hardware resources, and it is possible to reduce a development burden of hardware resources or a manufacturing cost of the system.

15 [0110] <Use of Device Information Data and Peripheral Information Data>

The storage unit 76C of the control device 7C of the binding system 1C stores the device information data 766C indicating the three-dimensional position of the entire surface of the binding device 6C and the peripheral information data 767C indicating the three-dimensional position of the entire surface of an obstacle around the robotic arm 4.

20 When the "binding direction" which is the binding condition is to be selected, the control unit 77C may determine whether the selection is possible by using the data 766C and 767C.

[0111] That is, since the device information data 766C includes the three-dimensional position data of the entire device surface of the binding device 6C, it is possible to acquire
25 each position of the surface of the binding device 6C in a state where the binding device 6C is supported by the end effector 43 of the robotic arm 4.

In the binding operation of the binding device 6C, when the binding device 6C is turned around the turning axis Zr according to the selection of the "binding direction", a possibility of interference between the binding device 6C and the obstacle can be determined
30 based on each position on the surface of the binding device 6C and the peripheral information data 767C indicating the three-dimensional position of the entire surface of the obstacle around the robotic arm 4.

Therefore, when the user selects the "binding direction" which is the binding

condition via the operation unit 72, the control unit 77C may determine the possibility of interference between the binding device 6C and the obstacle, and when there is a possibility of interference, the control unit 77C may perform a process of notifying that there is a possibility of interference via the display unit 73 or the like, a process of refusing the current selection of the "binding direction", or a process of automatically changing the current selection of the "binding direction".

Further, each of the above processes may be performed at a time point when the first binding condition data 764C or the second binding condition data 765C, the device information data 766C, and the peripheral information data 767C are prepared in the storage unit 76C.

Alternatively, the device information data 766C and the peripheral information data 767C may be prepared in the storage unit 76C, and the above process may be performed at a time point when the first binding condition data 764C or the second binding condition data 765C that may cause the interference is selected by the user to perform the binding process of the workpiece B.

[0112] <Other Matters in Present Embodiment>

The embodiments of the present invention have been described above. However, the present invention is not limited to the above-described embodiments. For example, in the embodiments, a component integrally formed by a single member may be replaced with a component divided into a plurality of members and coupled or fixed to each other. A component formed by coupling a plurality of members may be replaced with a component formed integrally by a single member. In addition, the details described in the embodiments can be appropriately changed without departing from the gist of the invention.

[0113] Further, in the present embodiment, in the binding system 1C, the user selects the binding conditions by the operation unit 72, but the present invention is not limited thereto.

For example, the user may select the setting conditions using an information processing terminal or the like not included in the binding system 1C to create the first binding condition data 764C, and the control device 7C of the binding system 1C may be configured to acquire the first binding condition data 764C by communication or acquire the recording medium on which the first binding condition data 764C is recorded through the reading device.

[0114] The binding system 1C may be configured to acquire the information on the intersections P for specifying the respective intersections P of the workpiece B only from the

map data 763C. In that case, in the binding system 1C, the first camera 31 and the second camera 51 are not essential.

However, since the binding device 6C can be more accurately positioned with respect to the intersection P by the second camera 51, only the first camera 31 may be omitted, and the second camera 51 may be provided.

When the first camera 31 is omitted from the configuration of the binding system 1C, the rail 22 and the driving motor 23 of the workpiece holding unit 2 that cause the workpiece B to move between the imaging area E1 and the binding area E2 can also be omitted.

[0115] In the binding system 1C according to the present embodiment, the binding device 6C that binds the reinforcing bars S with two wires W has been exemplified, but the present invention is not limited thereto, and a binding device that binds the reinforcing bars S with one or three or more wires W may be used.

[0116] In the binding system 1C, a configuration in which the binding device 6C and the individual imaging unit 5 are moved by the robotic arm 4 has been exemplified, but the present invention is not limited thereto. For example, the binding device 6C and the individual imaging unit 5 may be mounted on a head of a gantry-type mobile apparatus in the X-Y direction, and then the binding device 6C and the individual imaging unit 5 may be lifted and lowered along the Z direction from the head and may be turned around the axis along the Z direction.

Alternatively, the binding device 6C and the individual imaging unit 5 may be mounted on a self-propelled mobile apparatus that moves the workpiece B held in a grid pattern.

[0117] In addition, the binding system 1C according to the present embodiment is a stationary binding system disposed or fixedly installed in an indoor work space. Therefore, it is possible to perform the binding work without being affected by the weather or the outdoor environment, unlike an outdoor work-type binding system. Since a need for a device treated with waterproof, dustproof, high-temperature, and low-temperature countermeasures to withstand a severe outdoor environment is eliminated, it is possible to mount a device that performs precise work indoors, and to perform precise binding work on the workpiece B.

However, by excluding these advantages, it is also possible to configure a binding system having features in the present embodiment with respect to an outdoor use-type binding system.

[0118] The present application is based on Japanese Patent Application No. 2024-013041 filed on January 31, 2024, the contents of which are incorporated herein by reference.

INDUSTRIAL APPLICABILITY

- 5 [0119] A binding system allowing selection of a binding condition of a binding body at an intersection, and capable of performing binding work corresponding to various requirements on a workpiece is provided.

REFERENCE SIGNS LIST

- 10 [0120] 1C binding system
6C binding device
61C reinforcing bar binding machine
62C slack forming unit
7C control device
15 72 operation unit (condition input unit)
76C storage unit (recording device)
761C binding processing program
77C control unit (intersection information acquisition unit, intersection specifying
unit)
20 P intersection
S reinforcing bar
B workpiece
W wire (binding body)

CLAIMS

[Claim 1]

A binding system that performs binding on a workpiece, having an intersection at which reinforcing bars intersect, at the intersection with a binding body, the binding system
5 comprising:

a control unit configured to allow selection of a binding condition of the binding body at the intersection.

[Claim 2]

10 The binding system according to claim 1, wherein
the workpiece has a plurality of the intersections, and
the control unit allows a binding order of the binding body at the plurality of intersections to be selected as the binding condition.

15 [Claim 3]

The binding system according to claim 2, wherein
the control unit allows selection of an operation mode for specifying the binding order of the binding body at the plurality of intersections.

20 [Claim 4]

The binding system according to claim 3, wherein
in the operation mode, binding with the binding body at the plurality of intersections is performed from an outer edge of the workpiece along the outer edge.

25 [Claim 5]

The binding system according to claim 2, further comprising:
a condition input unit for the binding condition, wherein
the control unit performs binding with the binding body at the plurality of intersections according to the binding condition input from the condition input unit.

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[Claim 6]

The binding system according to claim 1, further comprising:
an intersection information acquisition unit configured to acquire information on the

intersection; and

an intersection specifying unit configured to specify the intersection at which binding with the binding body is to be performed, based on the acquired information on the intersection of the workpiece.

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[Claim 7]

The binding system according to claim 1, further comprising:

a recording device configured to record information on the intersection acquired from an outside of the binding system.

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[Claim 8]

A binding processing program causing a computer that controls a binding system that performs binding on a workpiece, having an intersection at which a plurality of reinforcing bars intersect, at the intersection with a binding body, to implement a function of allowing selection of a binding condition of the binding body at the intersection.

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